AN922
Application note

Using a Super Cap to back up the M41T56, M41T00 M41T11, M41T81, M41T94, and M41ST84W (16-pin)

Introduction

The M41T56, M41T00, M41T11, M41T81, M41T94, and M41ST84W (16-pin) real-time clocks (RTCs) from STMicroelectronics are used by applications designers who need a single chip device that offers fast SRAM storage and an integrated real-time clock (the M41T00 and M41T81 provide the real-time clock only). Many of their designs switch in a battery to maintain the data and keep the clock running when the external power supply falls below specification (or is completely absent). When the battery is depleted, though, the designer or user can be faced with the issues of replacement and disposal (see the application note AN1011, “Battery technology used in NVRAM products from ST”).

This document describes a more maintenance-free way to sustain the data and clock in systems that only experience short breaks in the power supply (on the order of days). A Super Cap can be used as a type of secondary cell (a rechargeable battery) and can therefore provide an alternative solution to using a primary cell. *Figure 1 on page 2* (for the M41T56) and *Figure 2 on page 4* (for the M41T00, M41T11, M41T81, and M41T94 as well as for the 16-pin M41ST84W) show two typical circuit arrangements. Since the Super Cap is limited to a certain maximum charging current, a series-limiting resistor may also be required (please consult the datasheet for the Super Cap).

In this document, the reliability, leakage current, and charging cycle limitations of the Super Cap have not been taken into account. Please consult the datasheet of the Super Cap for details.

Calculating the values of the circuit components for the M41T56

The minimum battery voltage for this device is 2.5 V, while the maximum battery supply voltage is 3.5 V. This gives the maximum delta voltage swing across the capacitor (1.0 V).

Note: Charging the capacitor above 3.5 V will result in a higher power-fail deselect voltage (V_{PFD}) trip point, and may cause inadvertent deselection of the device at nominal V_{CC} values.

$$V_{PFD} = 1.25 \times V_{BAT(typ)}$$

The voltage divider provides a bias on the transistor; the resistor divider is calculated according to the ratio of V_{CC} to V_{BASE}. Limit the maximum voltage charge on the capacitor using the formula:

$$V_{BAT} = V_{BASE} - V_{BE}$$

Derive the maximum voltage as follows:

$$V_{BASE} = MaximumSupplyVoltage + V_{BE}$$

Maximum supply voltage is 3.5 V; V_{BE} is typically 0.6 V, so the typical value of V_{BASE} is 4.1 V.

Recommended starting values for R1 and R2 are R1= 22 kΩ and R2 = 100 kΩ (with V_{CC} = 5 V). Since the battery current, "I_{BAT}," is limited to a maximum value of 550 nA, the capacitance and the duration of "power-out time" can be calculated using the formula:

$$I = C \times \frac{\Delta V}{\Delta t}$$

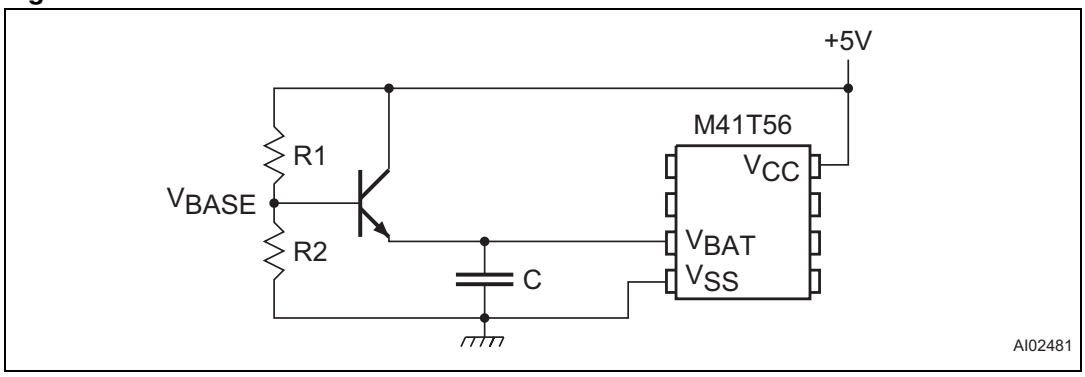
where I = 550 nA, ΔV = 1.0 V, C = capacitance is in "Farads," and Δt = "power out time" is in "seconds."

Using a 100,000 µF capacitor, for example, the equation would be:

$$550nA = 0.1F \times \frac{1.0V}{\Delta t}$$

Solving for Δt, the maximum power down time is about 181,818 seconds. This is just over two days.

Figure 1. External connections to the M41T56



Calculating the values of the circuit components for the M41T00, M41T11, and M41T81

The minimum operating voltage for these devices is 2.0 V, with a typical V_{BAT} voltage of $V_{CC} - V_F$ (diode).

Therefore, the typical delta voltage swing across the capacitor is:

$$\Delta V = V_{CC} - V_F - V_{CC}min$$

where V_F is approximately 0.5 V. Therefore:

$$\Delta V = 5.0V - 0.5V - 2.0V$$

$$\Delta V = 2.5V$$

Since the battery current (I_{BAT}) is limited to maximum value of 1.0 µA, the capacitance and the duration of “power-out time” can be calculated using the formula:

$$I = \frac{C\Delta V}{\Delta t}$$

where I = 1.0 µA, ΔV = 2.5 V, C = capacitance in Farads, and Δt = “power-out time” in seconds.

Using a 100,000 µF capacitor, for example, the equation would be:

$$1.0\mu A = 0.1F \times \frac{2.5V}{\Delta t}$$

Solving for Δt, the maximum power down time is about 250,000 seconds. This is 69.4 hours, or 2.9 days.

Calculating the values of the circuit components for the M41ST84W and M41T94

The minimum operating voltage for these devices is 2.5 V, with a typical V_{BAT} voltage of $V_{CC} - V_F$ (diode).

Therefore, the typical delta voltage swing across the capacitor is:

$$\Delta V = V_{CC} - V_F - V_{CC}min$$

where V_F is approximately 0.5 V. Therefore:

$$\Delta V = 5.0V - 0.5V - 2.5V$$

$$\Delta V = 2.0V$$

Since the battery current (I_{BAT}) is limited to the maximum value of 500 nA, the capacitance and the duration of “power-out time” can be calculated using the formula:

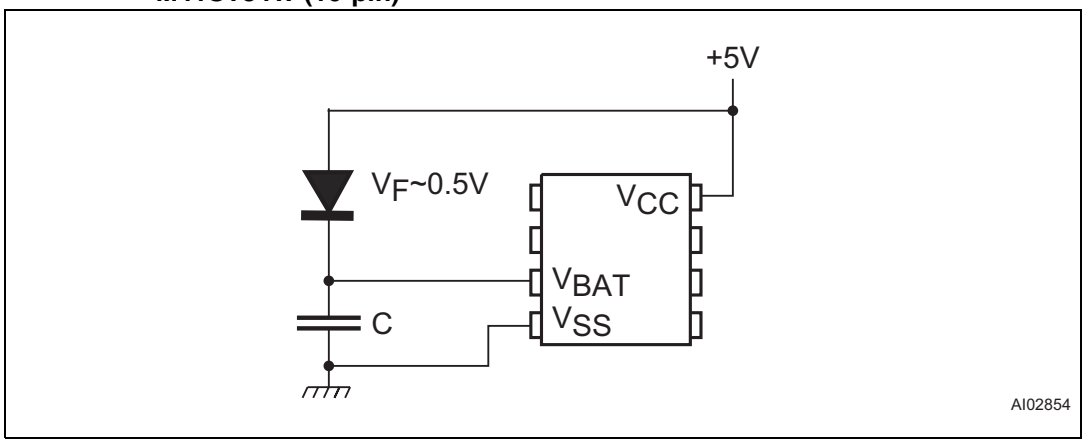
$$I = \frac{C\Delta V}{\Delta t}$$

where I = 500 nA, ΔV = 2.0 V, C = capacitance in Farads, and Δt = “power-out time” in seconds. Using a 100,000 µF capacitor, for example, the equation would be:

$$500nA = 0.1F \times \frac{2.0V}{\Delta t}$$

Solving for Δt, the maximum power down time is about 400,000 seconds. This is 111.1 hours, or 4.63 days.

Figure 2. External connections to the M41T00, M41T11, M41T81, M41T94, and M41ST84W (16-pin)



Revision history

Table 1. Document revision history

Date	Revision	Changes
Feb-2002	1	Initial release.
19-Sep-2011	2	Product updates; minor textual updates; revised document presentation.

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